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SIMPLEST IMPLEMENTATION TO ERADICATE ARTIFACTS IN WRIST PULSE SIGNALS

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Abstract:

Wrist Pulse Signal (WPS) is a common method of finding the diseases in human body. It is non-invasive method of measuring health status with no risk to the subject. The analysis of WPS depends on a number of factors such as amplitude, time and frequency. The time series of WPS shows the variation in amplitude and time period within successive cycles due to motion artifacts. The presence of artifacts (invalid /irregular pulse) adversely affects in the classification of disease. In the present investigation, simplest algorithm was used for identification and elimination of artifacts using ®LabVIEW. The experimental results showed that the valid pattern of WPS collection has been done in an easy manner. The cogency of the implemented method was verified through a comparing the parameters of WPS with and without eradicating artifacts. This automated valid/invalid pulse identification system has identified 70.55% of average valid pulses from the acquired WPS.

Keywords: Biomedical Signal Processing, Algorithm, Traditional Indian Medicine, Artifacts, Ayurveda, LabVIEW, Wrist Pulse Signal(WPS)

1. Introduction

Ayurveda, the Traditional Indian Medicine (TIM), originated in India several thousand years ago [1]. The system basically aims to promote health and raise the standard of life.

Traditionally, ayurveda practitioners use their fingertips to feel the pulse sensations on the wrist as shown in Fig. 1, called as wrist pulse signal (WPS) diagnosis [2].

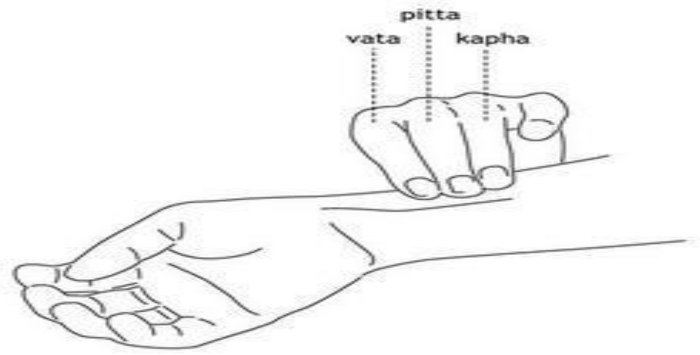

Fig.1: Traditional way of Pulse Diagnosis.

The basis of WPS diagnosis lies in three radial pulses which are known as vata, pitta, and kapha (together known as tridosha). They exhibit different characteristics that can be reflected through extracted WPS features which are considerably important from the perspective of pulse diagnosis [3]. A lot of training and experience is required to master the art of pulse diagnosis. As it is skill based, the results may vary from one practitioner to another [4]. Certainly supervising and quick decision-making will be difficult by all human beings for WPS. Consequently, it is needful to set up a smart system (computerized wrist pulse diagnostic system) that can contribute to modernization of traditional practice of pulse diagnosis. In order to detect the pathological changes in the body, pulse diagnosis is gaining importance in recent times [5].

WPS may comprise artifacts, such as movement artifacts or muscle contraction artifacts. In biomedical terms, artifacts can be referred as something that is not 'heart-made'. Artifacts in WPS could be recognized by experienced ayurvedic physicians and they could analyze WPS without any problem. Artifacts are very common and study related to them is required to prevent misinterpretation of the signals created by heartbeat. The crucial step in the WPS is to identify and eliminate artifacts. During the process of data acquisition of WPS, artifacts become apparent. Due to the presence of artifacts irregular pulse/ invalid pulses pattern appear in the WPS. Artifacts that emerge during data acquisition are required to be eliminated using irregular pulse detection method.

Recently researchers started to address this problem more closely. Studies in various fields like health monitoring systems, fault detection, detection of ecosystem disturbances, etc. deals with periodic (regular) and non-periodic (irregular) patterns of data. It was observed in [6], the patterns in data series that do not conform to expected behavior were commonly known as outliers. In biomedical, outliers can also be termed as artifacts. Receiving such wide recognition has led to the development of many detection methods to identify and remove these artifactual irregular pulses, especially for the physiological artifacts. In [7], authors were discussing the influence of motion artifacts on the extraction of reliable cardiovascular parameters for continuous real time monitoring applications. A dynamic time warping algorithm was used by [8] for the identification of an outlier pulse. They highlighted how the pulses lose their character and also mentioned that pre-processing alone not enough efficient to remove the artifacts completely. A nonartifactual pulse recognition algorithm was proposed to locate and eliminate the artifactual irregular pulses in intracranial pressure signal by [9]. In [10], researchers concluded that outlier waveforms with too long or too short length were omitted using a thresholding based method. Moreover, Neural network techniques have been implemented for outlier detection. SVM with linear kernel classifier was applied to distinguish abnormal pulses from healthy pulse patterns in [11] and achieved the highest success rate of 99.2%. Authors in [12] also used SVM classifier to discriminate among artifact conditions. Researchers in [13], discussed about ECG and electromyography artifacts in brain computer interface. Similarly, in WPS electromyography artifacts presents and they need to be removed. Having a suitable artifact recognition and elimination algorithm may help to perceive WPS data in a better way for disease detection. A review of the existing literature did not reveal any straightforward artifact identification and elimination method in WPS. Therefore, in this paper effort has been made to implement the simple and efficient method for identification of artifact and elimination. The rest of the paper is organized as follows. Section 2 provides the details of WPS data acquisition and Section 3 discussed pre-processing and proposed approach under material and methods. Section 4 presents the simulation results. Finally, concluding remarks are given in Section 5.

2. Data Acquisition System

Data acquisition begins with the physical phenomenon to be measured. By placing a pressure sensor at the radial artery, collection of the WPS is carried out. The hardware consists of LPF and amplifiers, having a cutoff frequency of 10 Hz. After the filtration and amplification of raw signal, real time acquisition of WPS using NI-DAQ Card has been done. Its primary function is to digitize the incoming analog signals so that computer can process and analyze the information in terms of digital values. In the present investigation, in all 4 subjects were participated, the WPS have been captured for 60 sec and the data set includes females of same age group 25-28 years with no disease in order to avoid variation in results due to age, gender and health conditions. The acquired signal resembles well with the standard pulse from the radial as shown in Fig. 2 & 3.

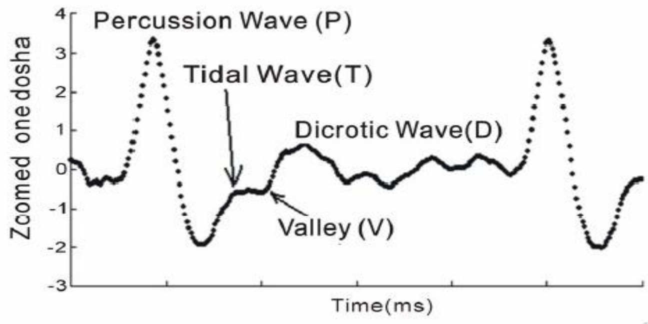

Fig. 2: A standard signal from the radial artery [14].

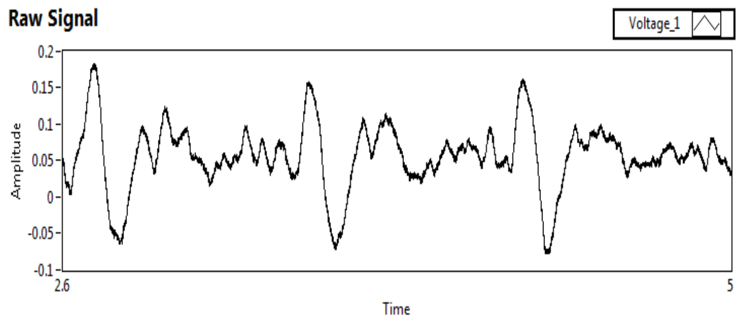

Fig. 3: Acquired Raw Signal.

3. Material and Methods:

3.1. Preprocessing

The pre-processing is obligatory for feature extraction and analysis to work correctly. WPS series show beat to beat variations because of physiology of human body. At the time of acquisition some of the pulses are highly affected by noise and motion artifacts. The processing of the contaminated or noisy signal gives false information that lead to incorrect results. To avoid such problems, pre-processing of raw pulse signal is necessary. The whole process of WPS data recording and preprocessing is represented in the flowchart as shown in Fig. 4.

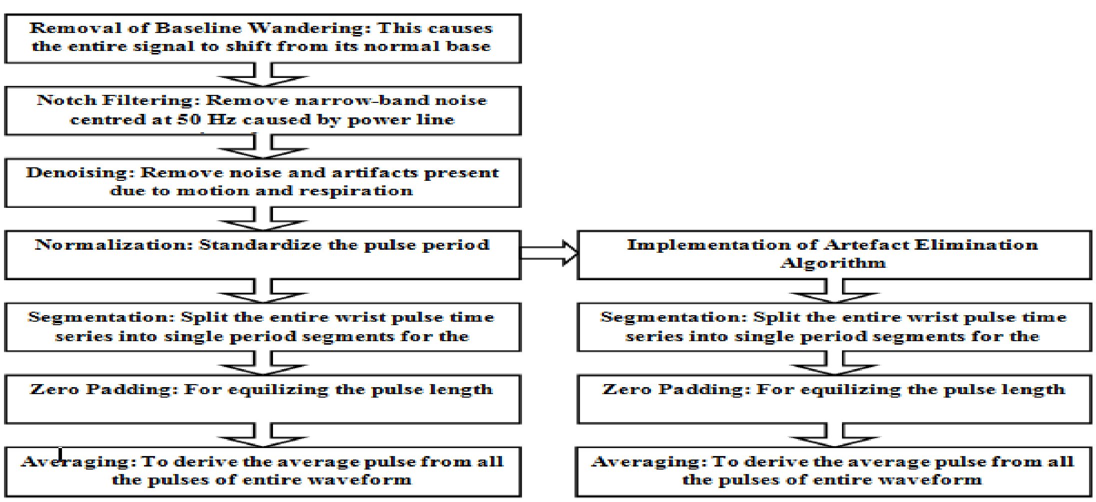

Fig.4: Flowchart representing whole process of Pre-processing (divide into two sections: with Artifacts and without Artifacts)

After preprocessing of raw WPS, the artifacts (irregular/ invalid pulses) remain in signal which intrudes the results. A slight movement by the person generates an unavoidable artifacts that results in few pulses losing their character and shows too high and too short amplitude and time periods within the acquired WPS as shown in Fig. 5.

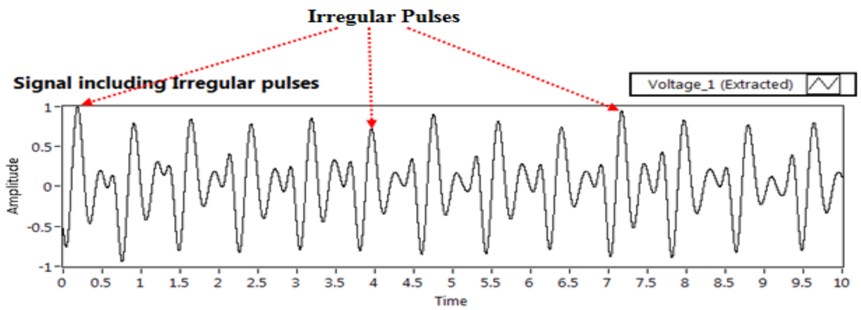

Fig. 5: WPS representing Artefactual Irregular Pulse.

The presence of artifacts is identified in WPS. The WPS features extracted from these affected pulses will affect the whole analysis as well as results. For the feature extraction and classification of disease it is required to remove the presence of motion artifacts initially. To eradicate the presence of these artifacts in WPS, the proposed algorithm is implemented after normalization and before segmentation.

3.2. Proposed Approach

For automated signal processing techniques, it is important that artefactual irregular/invalid pulses to be eradicated in order to avoid unfavorable effects. The investigation here focuses on abolishing these artefactual irregular pulse segments and comprising only valid pulse segments. The present research work proposes a simple method (inspired by [15]) to recognize and eradicate artifacts using ®LabVIEW Virtual Instrumentation. It helps in separation of artefactual pulses from the whole WPS for better analysis. Data acquired for 60sec from subjects having multiple segments or pulse periods. The validity of these pulse periods has been checked sequentially by considering a window of 7 pulses (3 before and 3 after and the present pulse) at one time. Two parameters are considered for checking the validity of a pulse i.e. Peak Amplitude (Hp) and Time Period (TP). Assessment for the peak validity is done beforehand time period validity within the same window for the same segment. Successively, evaluate the overall validity of the acquired signal in the percentage. Additionally, this section highlights the algorithm implemented to identify and eliminate artifacts from WPS. Following are the steps used for Irregular Pulse Recognition and Elimination Algorithm.

Step 1: Select the pulse segment and mark the percussion peak amplitude as *Hi* and time period as *TPi*

Step 2: Determine the average value of previous 3 and next 3 percussion peak amplitudes and mark it as *Hmi*

Step 3: Verify the condition |*Hi-Hmi*| ≤ *10% Hmi*

Step 4: If true goto next Step 5 else mark the pulse segment as Invalid and goto Step 9

Step 5: Determine the average value of previous 3 and next 3 pulse Time Periods and mark it as *TPmi*

Step 6: Verify the condition |*TPi-TPmi*| ≤ *10% TPmi*

Step 7: If true goto next Step 8 else mark the pulse segment as Invalid and goto Step 9

Step 8: Mark the pulse segment as Valid

Step 9: Select the next pulse segment and goto Step 1

Recognition of artifacts is achieved as described: for each pulse period under investigation, the mean value of amplitude Hmi and time duration TPmi of a window comprising three previous and later pulse wave periods are computed, where

Hmi = $\sum_{i-1}^{i-3} Hi + \sum_{i+1}^{i+3} Hi) \div 6$ .... (1)

TPmi = $\sum_{i-1}^{i-3} TPi + \sum_{i+1}^{i+3} TPi) \div 6$ .... (2)

Pulse segment validity conditions are

|Hi-Hmi| ≤ 10% Hmi .... (3)

|TPi-TPmi| ≤ 10% TPmi .... (4)

Valid peak and valid time period conditions has been verified for all the pulse segments successively and if both the conditions satisfied only then pulse segment is considered as a valid regular pulse otherwise the pulse segment determined as invalid/irregular pulse, henceforth eliminated from the time series as shown in Fig. 6. Our proposed explanation for identification and elimination of artifacts would be valuable for further WPS analysis.

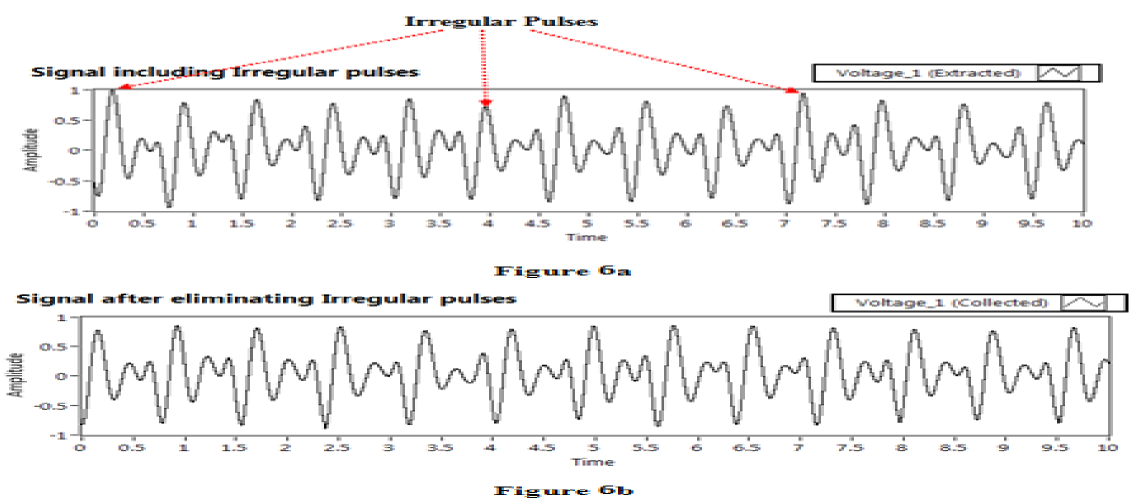

Fig. 6: Signal before and after removing Artefactual Irregular Pulses.

4. Experimental Results

Results in terms of waveform patterns were classified under two cases. In the first case, as shown in Fig. 7, the results showing variations in amplitude (Hp) and time period (TP) of subject S1 without eliminating irregular pulses.

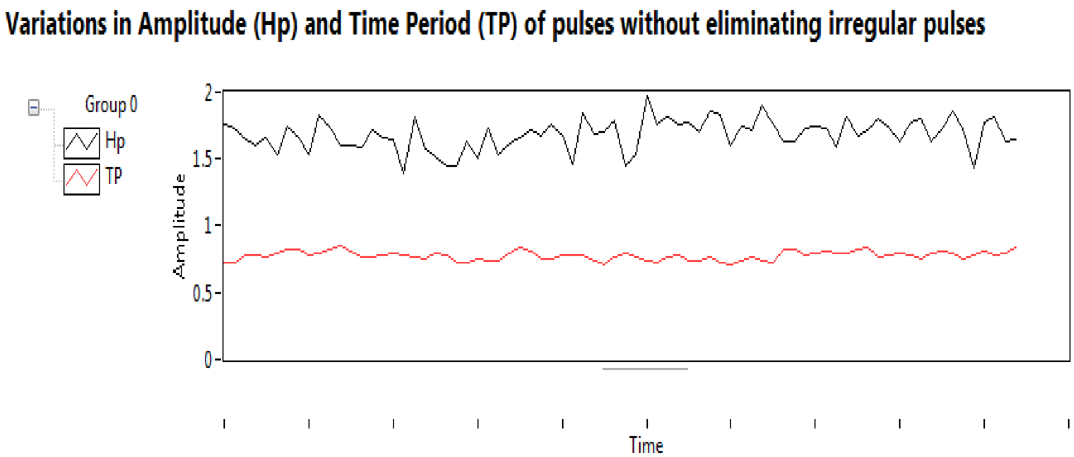

Fig. 7: Variations in range of Peak Amplitude (Hp) and Time period (TP) without eliminating artifacts (Case1) for Subject 1 (S1).

In second case has showing variations in amplitude (Hp) and time period (TP) for the same subject after eliminating irregular pulses as represented in Fig. 8.

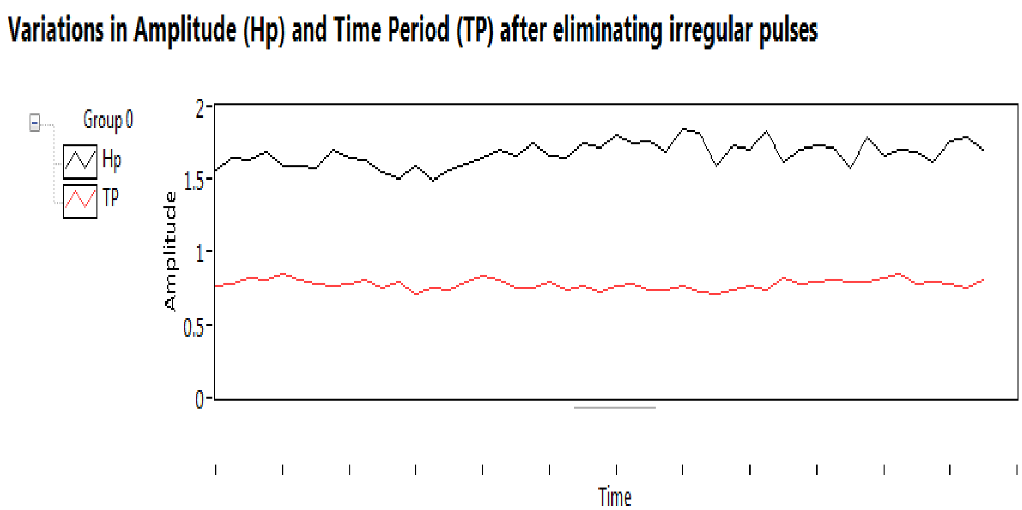

Fig. 8: Variations in amplitude (Hp) and time period (TP) of pulse series after eliminating irregular pulses (Case 2) for Subject 1 (S1).

Variability analysis was carried out on all the four signals with artifacts (Case 1) and without artifacts (Case 2). Percentage of variability in both the cases for all the signals (subjects 1 to 4, represented as S1, S2, S3, S4) has been represented in the form of bar graphs as shown in Fig. 9 & 10.

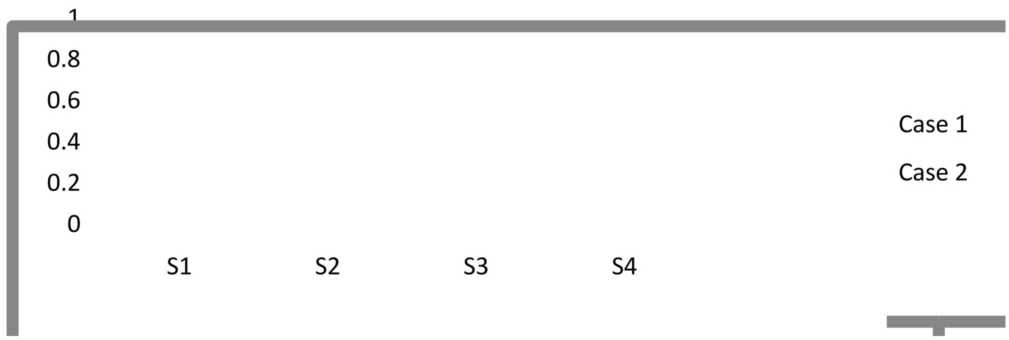

Fig. 9: Variations in range of Peak Amplitude (Hp) with (Case1) and without (Case2) artifacts.

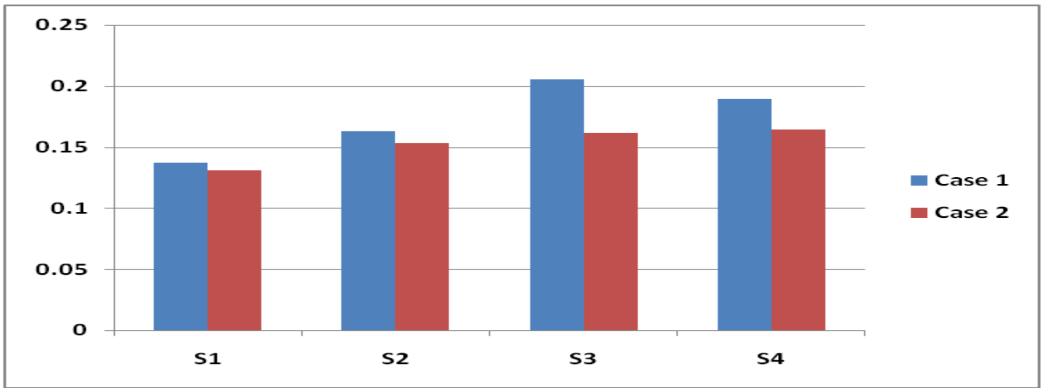

Fig. 10 Variations in range of Time Period (TP) with (Case1) and without (Case2) artifacts.

Peak Amplitude (Hp) and Time Period (TP) were the two parameters considered for percentage of variability analysis. Fig. 9 depicts the comparison of variations in percentage of Peak Amplitude (Hp) between case 1 and case 2. Similarly, Fig. 10 depicts the comparison of variations in percentage of Time Period (TP) between case 1 and case 2. However, before removal of irregular pulses, the percentage of variation of Hp and TP are higher as compared to percentage of variation after removal of irregular pulses. It indicates the rise in stability factor of wrist pulses after the irregular pulses have been removed. The outcome of all the four signals with respect to different parameters has been shown in Table 1.

Table 1: Outcome of Artifacts removing Algorithm

Subject / Parameter	S1	S2	S3	S4
Total number of Cycles	70	67	58	60
Valid number of Peaks (Hp)	48	50	41	41
Peak Percentage Validity	68.57%	74.63%	70.69%	68.33%
Valid number of Time Periods (TP)	70	67	55	60
Time Period Percentage Validity	100%	100%	94.83%	100%
Valid number of Cycles	48	50	41	41
Overall Percentage Validity	68.57%	74.63%	70.69%	68.33%

Comparing the results represented in Table 1 and Fig. 7-10, it was observed that the implementation of the proposed simple algorithm provides the valid pulses which includes the valid amplitude and time period pulses. The WPS collected after the proposed algorithm has rhythmic pulse segments without motion artifacts to extract the relevant information for further analysis. As the result, we can conclude that the artifacts can be eliminated from WPS by using the proposed method.

5. Conclusion

The proposed algorithm was applied on all the acquired signals. At the outset, we extracted the feature from the preprocessed WPS without eliminating the artifacts. In order to examine the efficacy of the proposed method, features were extracted after artifacts eliminated from WPS using the proposed method and then results were analyzed. The derived parameters showed lesser variation after eliminating artefactual irregular pulses. In this research work, a simple method is proposed to minimize the artifacts present in the WPS. This method recognized 70.55% of average valid pulses from acquired WPS. It is an effective method in eliminating the artifacts from WPS. Further, WPS would be used for classification of diseases in a better way.

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